Preliminary laboratory multi-scale investigation on performance of pervious concrete pavements and vegetated elements as storm water bio-filters and retention systems

5TH INTERNATIONAL ECOSUMMIT
ECOLOGICAL SUSTAINABILITY
ENGINEERING CHANGE

ecoSummit 29 August - 1 September, 2016 Montpellier, France

Preliminary laboratory multi-scale investigation on performance of pervious concrete pavements and vegetated elements as storm water bio-filters and retention systems

Presented: *Elena Comino, Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Italy*
elena.comino@polito.it

Authors: *Bassani M., Tefa L., Comino E., Rosso M., DIATI, Politecnico di Torino, Torino, Italy*
Garcia A., Ricci R., BioSEARCH Ambiente S.r.l., Torino, Italy
Bertola F., Canonico F., Buzzi Unicem S.p.A., Trino V.se, Italy

Research funded by: *REGIONE PIEMONTE (2015) POR-FESR 07/13 - Measure 1.1.3 - Code: 285 - 47*

Water collection from a urban pavement for the first and second investigation stages

MOTIVATIONS

1. World population in urban areas is still growing causing severe impact on environment and decrement of the life quality of inhabitants.
2. To smoothen the heavy impact of traditional transportation infrastructures, current and future urban facilities must be more environmental friendly and sustainable.
3. One way is to develop new "green transportation infrastructures" (GTI) as part of the urban storm water management system.
4. GTI have been well-investigated around the world, but specifically in Italy there is still a limited experience on their potential and benefits.
5. This work aimed promoting new urban storm water regulation systems through retention, filtration, and restoration of natural soil water content, and involving different expertise and knowledges.
6. A laboratory investigation on porous road pavements, and vegetated boxes, used to filter runoff pollutants from impervious pavements, was carried out to examine their ecological, hydraulic, and mechanical performances.

Three different experimental scales (samples, columns, and boxes) and investigation stages for the two GTI technologies were considered.

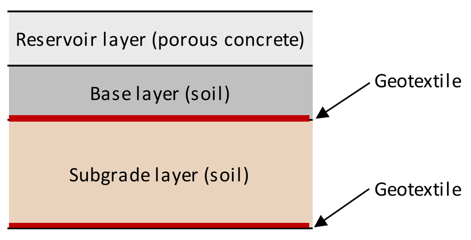
FIRST STAGE Sample scale

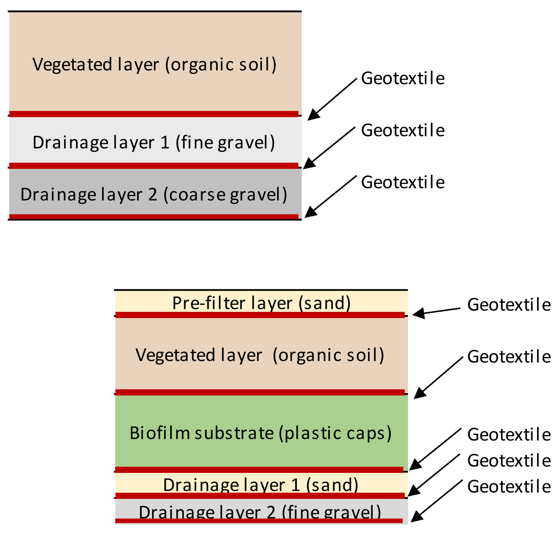
Pollutant [μg/l]/Materials	Input stormwater	Sand	Organic soil	Compost	Clay	Plastic caps	Geotextile	Subgrade soil
Susp. Solids	1127	518	73	128	145	113	37	3
Hydrocarbons	2700	33	110	27	930	380	0	29
Cadmium								
Chrome	0,1	0,0	0,2	0,2	0,1	0,1	0,1	2,1
Iron	11,9	1,7	22,0	27	11	16	3,7	0,08,0
Manganese	8,0	20,0	0,4	0,5	13	10	0,2	0
Nickel	1,2	1,2	1,0	2,3	5,8	1	0,5	0,6
Lead								
Copper	2,6	1,7	1,7	2,1	3,7	1,8	1,1	3,5
Zinc	5,1	1,3	3,5	3	8,5	8,6	2,2	0,3

This preliminary stage assessed the pollutant reduction capability operated by each of the different materials to choose the best ones to prepare the layers of bio-filtering columns first and then boxes.

SECOND STAGE Column scale

Pervious concrete pavement column

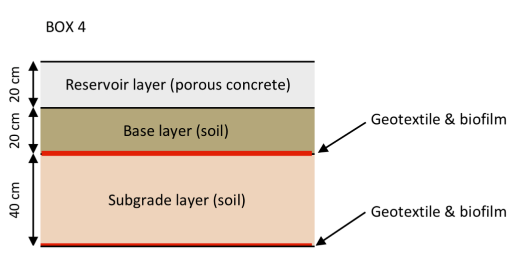


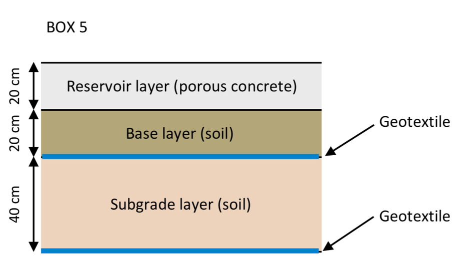


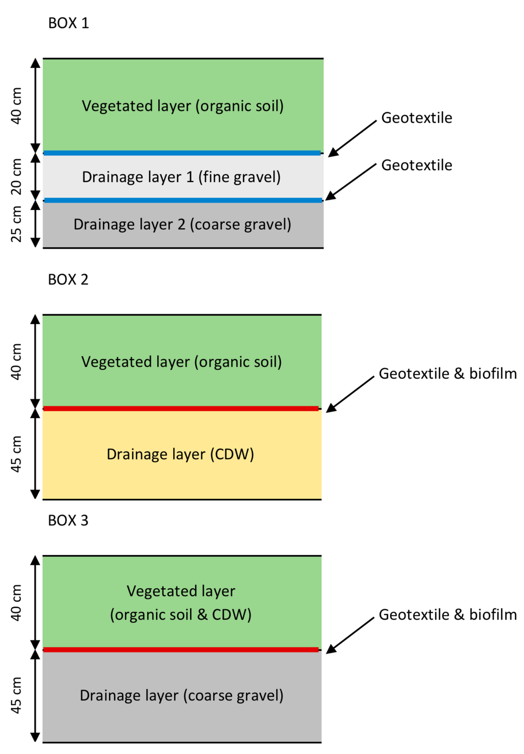
The columns experiments represent the second stage of the research giving precious information to construct the "real scale" box filters developed in the third phase. For each materials All the relevant parameters has been measured: grading analysis, density, porosity, permeability, mechanical strength.

THIRD STAGE Box scale

Pervious concrete pavements







1:1 scale boxes were used to evaluate the real performances of the different proposed techniques. Pervious pavements were carefully reproduced in lab using the usual on site construction procedure.
Vegetated modules represent, with different materials and stratigraphy, the new, or existing, rain garden or swales preparation in order to maximize the positive effects on depuration and runoff reduction.

← Vegetated boxes.

Pavement and vegetated systems were saturated for 12 hours with stormwater prepared in laboratory. Water samples were then collected and analysed.

RESULTS

COLUMNS SCALE

Pollutant [μg/l]	Input stormwater	Pervious pavement column	Vegetated column
Susp. Solids	1127	4	82
Hydrocarbons	12000	79	67
Cadmium	0,2	0,0	0,6
Chrome	3,8	1,3	8,8
Iron	1100,0	20,0	2200,0
Manganese	210,0	295,0	505,0
Nickel	15,0	9,5	125,0
Lead	10,4	38,0	12,5
Copper	41,5	7,7	79,5
Zinc	130,0	2500,0	1050,0

BOXES SCALE

	Input stormwater	Box 1 - Vegetated natural without biofilm			Box 2 - Organic soil and CDW with biofilm		Box 3 - CDW and gravel with biofilm		Box 4 - Pervious pavement with biofilm		Box 5 - Pervious pavement without biofilm	
Depth [cm]	-	40	60	80	40	80	40	80	40	90	40	90
Pollutant [μg/l]	-	Organic soil	Gravel 5-15 mm	Gravel 15-30 mm	Organic soil	CDW aggregates	Organic soil & CDW	Gravel 15-30 mm	Pervious concrete & base	Subgrade	Pervious concrete & base	Subgrade
Susp. solids	1000	10500	10200	9400	10500	12200	10100	7600	14800	43300	16300	14000
Hydrocarbons	117000	860	670	550	860	560	550	570	10500	1500	740	670
Cadmium	17,5	0,0	2,0	0,0	0,0	0,1	0,0	0,1	0,1	0,2	0,0	0,0
Chrome	7,0	2,0	Inf. 50	4,0	2,0	54,0	6,0	6,0	5,0	8,0	8,0	14,0
Iron	34,0	34,0	Inf. 50	34,0	34,0	32,0	45,0	32,0	12,0	192,0	15,0	39,0
Manganese	107,0	33,0	50,0	12,0	33,0	44,0	13,0	4,0	3,0	17,0	3,0	4,0
Nickel	2,0	26,0	57,0	57,0	26,0	23,0	11,0	30,0	2,0	2,0	3,0	2,0
Lead	51,0	0,0	10,0	0,8	0,0	1,3	1,1	2,9	0,0	5,8	0,0	1,9
Copper	67,0	14,2	27,0	36,9	14,2	17,6	10,9	19,5	2,9	6,8	4,5	10,0
Zinc	272,0	52,0	52,0	54,0	52,0	31,0	49,0	73,0	21,0	39,0	10,0	28,0

CONCLUSIONS

- ✓ The three scales provided consistent results that were used to develop step by step the three stages of this laboratory investigation
- ✓ Variations of heavy metal contents were found to be dependent on the type of material used in each column/box
- ✓ The two GTI technologies performed very well in case of hydrocarbons treatment, since they reduced it for more than 90%
- ✓ The CDW additions has the positive effect to increase the porosity of the medium using waste material and no negative polluting effects (it is recommended to test in advance the potential release of the different mixtures used)
- ✓ The added bacteria bio-film do not increase the pollutants abatement due to the strong environment influence
- ✓ GTI technologies are effective in the reduction of pollution in water runoff, and can improve the performances of urban storm water management systems.